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kilowatts. The steam, consequently, after being heated to 300° Celsius, drives the turbine, and this, in turn, impels the dynamo which makes the electricity. After passing through the turbine, the steam is cooled in a condenser and is then pumped back into the boilers.

The electricity thus manufactured is sold to the municipal electric works (*i. e.*, owned and controlled by the city) at 3½ pfennigs (less than one cent) per kilowatt hour, and the electric works in turn sell the same to the public at 11 pfennigs (2.718 cents) per kilowatt hour. Whenever the garbage incinerator requires electricity for its own use, as for lighting, etc., on Sundays and holidays (ordinarily it furnishes its own electricity), it is obliged to procure this from the municipal works at the regular price of 11 pfennigs. Inasmuch as the garbage cremating plant is also a municipal institution, there eventually is not much advantage or disadvantage either way, as the money belongs to the city under any circumstances, the only difference being in the showing made by the various departments.

The garbage which is thus utilized for the manufacture of commercial products is practically every manner of refuse in existence: rags, paper, household waste, old clothing, and in fact every sort of material usually consigned to the dump heap.

From the garbage brought to the cremating plant 50 per cent. in weight and 30 per cent. in volume goes into the finished product, the sand. That is to say, 100 lbs. of garbage will produce 50 lbs. of sand, while from 100 cubic meters of garbage 30 cubic meters of sand will result.

When once started, the furnaces remain in operation uninterruptedly. The men performing the labor about the plant work in two shifts, from 6 A.M. until 2 P.M. and from 2-10 P.M. At that hour the last charge of garbage is banked so as to burn until the next morning. There is no coal or coke fire of any description, the garbage being its own and only fuel.

The efficiency of the Barmen incinerating

plant lies chiefly in the construction of the furnace grates, these being V-shaped, but rounded at the base, and constructed from heavy cast iron. Along the sides of each grate are grooves in which are found minute holes at intervals of about three inches. Through these small holes a strong air current strikes the burning garbage, thus furnishing the necessary draft for combustion and aiding the process of cremation to a considerable extent. In other furnaces these holes are at the bottom of the grates and the wind reaches the fire from below, but it has been found that in this case the application of the air current is a too local one, not reaching the entire burning surface and often merely blowing through the fuel. By the Barmen method the air current, forced into the furnace by powerful pumps, strikes the burning garbage from the sides and from above at an angle, and together with the differing shape of the grate and the grooved sides thereof this method has proved most efficient.

The annual production of the plant amounts to 11,000 tons of slag or clinkers (which are crushed into sand as above explained) from 22,000 tons of garbage, while 1,700,000 kilowatt hours is the annual output in electricity.

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#### SPECIAL ARTICLES

##### A POSSIBLE MENDELIAN EXPLANATION FOR A TYPE OF INHERITANCE APPARENTLY NON- MENDELIAN IN NATURE

As research in genetic problems proceeds, the work of many investigators shows that in all probability certain characters of the organism depend for their visible manifestation in the zygote upon the simultaneous presence of more than one mendelizing factor.

One of the classic examples of this condition is that of the inheritance of the walnut comb in fowls reported by Bateson<sup>1</sup> (1909,

<sup>1</sup> Bateson, W. (1909), "Mendel's Principles of Heredity," Camb. (Eng.) University Press.

p. 60). The chief point of interest in this investigation was the fact that the simultaneous presence in the zygote of R, the factor for rose comb, and P, the factor for pea comb produce an entirely new character, namely, the *walnut comb*. Two walnut-combed birds produced by a cross of pea comb  $\times$  rose comb gave, when crossed together, an  $F_2$  progeny consisting of walnut, rose, pea and single comb, in a ratio of 9, 3, 3, 1.

A similar result would be obtained if the parents used in the original cross were walnut comb of the formula RRPP and single comb rrpp.

In this last case if we focus our attention on the walnut comb we should see that it recurred in approximately 9 out of 16 of the  $F_2$  progeny.

A character dependent solely upon one mendelizing factor is present in three fourths of the  $F_2$  progeny. The ratio of those lacking it to those having it being as 1:3. When, however, two factors are needed for the manifestation of a character, as in the case of the walnut comb, the character is lacking in a far greater number of  $F_2$ , namely, in 7 out of 16. The ratio of those lacking the character in question to those having it becomes 1:1.3 instead 1:3, as in the case involving only one factor.

If three factors are necessary for the manifestation of a given character, the  $F_2$  ratio shows a still greater proportionate increase of animals lacking the character. If the simultaneous presence of factors A, B and C is necessary for the manifestation of a given character, the number showing the character in  $F_2$  may be calculated as follows:  $F_2$  will be made up of 27ABC, 9ABc, 9AbC, 9aBC, 3abC, 3aBc, 3Abc, 1abc. Only the 27 ABC animals will show the character question, and the ratio of those lacking the character to those having it will be as 1.3:1.

An actual cross of this sort is the following: a wild black agouti mouse having the factors B for black, A for agouti and D for intensity was crossed with a dilute brown mouse having the factors b for brown, a for non-agouti and dil for dilution.

$F_1$  animals were all Aa Bb Ddil, all of them having the character in question, namely, *intense black agouti pigmentation*.

When these  $F_1$  animals are crossed together they should give a ratio of 27 intense black and 140 other colors, while the expected numbers obtained were 107 intense black agouti and 140 other colors, while the expected numbers are 105.3 intense black agouti and 141.7 other colors, respectively.

Another cross with mice recorded by Phillips and the writer<sup>2</sup> (1913) will serve to illustrate the case of four factors. Here the ratio expected is one animal having the character in question, to 2.16 lacking it.

From Table I.<sup>3</sup> it will be seen that there are in  $F_2$  436 animals possessing the character in question (intense black agouti) to 744 lacking it, the expected numbers being 373 to 807.

As the number of factors increases, the ratio of animals which *do not* show the character to those that do increases rapidly.

With 10 factors it becomes 16.7:1, with 15 factors, 73.8:1, and with 20 factors 314.3:1.

It will be convenient to present this in tabular form as follows:

Number of Factors	Ratio of Animals Lacking Character to Those Having It
1	1:3
2	1:1.3
3	1.3:1
4	2.1:1
5	3.2:1
10	16.7:1
15	73.8:1
20	314.3:1

The general principle involved is that, with the addition of each factor involved, the number of  $F_2$  animals possessing the character in question is multiplied by three, while the *total* number of  $F_2$  zygotes is multiplied by four. It will be seen, therefore that the difference between the number of animals *with* the char-

<sup>2</sup> Little, C. C. (1913) and Phillips, J. C., "A Cross Involving Four Pairs of Mendelizing Characters in Mice," *Am. Nat.*, Vol. 47, pp. 760-762.

<sup>3</sup> *Loc. cit.*, p. 761.

acter and those *lacking* it grows progressively greater with each factor added.

The practical value of the principle may prove to be considerable as it serves to explain cases in which a character dominant in  $F_1$  almost completely disappears in  $F_2$ , and in which an apparently non-mendelian result is obtained involving a reversal of dominance.

For supposing that a certain character,  $x$ , depended for its visible manifestation upon the simultaneous presence in the zygote of 20 factors which we may designate as A, B, C . . . T. Then if an animal possessing this character and the above mentioned factors is crossed with one from a race lacking all these factors,  $F_1$  would all be of the formula  $Aa Bb Cc . . . Tt$ . All would develop the character in question since all had a single representation of the twenty factors. If, however, these  $F_1$  animals were bred inter se  $F_2$  would give approximately only one animal in 314 which had the character in question. If only a small number of  $F_2$  were raised the character might well be thought lost and perhaps not truly inherited by  $F_1$ .

An entirely different result would, of course, be obtained if the factors in question needed to be present in *all* the gametes of the zygote in order for the character to be visibly manifested. In such a case as this none of  $F_1$  would show the character, and its reappearance in  $F_2$  would follow the ordinary rules of mendelian segregation and recombination.

This note is merely offered in the hope that it may be of use in the explanation, on a Mendelian basis, of certain results which might otherwise be offered as examples of non-mendelian inheritance.

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#### THE STRUCTURE OF THE COTTON FIBER

IN any kind of cotton the typical fiber, that is the one in which all the essential parts may be determined, can be found in rare cases. For this reason the structure of an ideal fiber can be inferred only from a series of studies of fibers in successive stages of development.

By subjecting such fibers to certain chemical and bacteriological treatments and then studying them under the microscope, we found that the typical cotton fiber consists of the following parts:

1. The outer layer or the integument.
2. The outer cellulose layer.
3. The layer of secondary deposits.
4. The walls of the lumen.
5. The substance in the lumen.

1. *The outer layer or the integument* is the incrusting layer and forms the cementing material of the fiber. Its chemical structure is not an homologous one, but is a mixture of components, some soluble in alcohol, some in ether, and some in water. The components are cutinous, pectinous, gummy, fatty and other unidentified bodies.

2. *The outer cellulose layer* is in its structure a distinct spiral, consisting of a limited number of component fibers, perhaps of one or of two. The structure of this layer is determined under the microscope from a longitudinal section of the fiber after the latter has been subjected to a series of chemical and bacteriological treatments. Careful treatment of some of the fibers by cuprammonia will show under the microscope this spiral. There is some evidence to show that this spiral consists of impure cellulose.

3. *The layer of secondary deposits* seems to be made up of component fibers which in no case have shown a spiral structure. Unlike the fibers of the above described layer, these components are from about five to ten in number and run with some irregularities along the length of the fiber.

4. The structure of the layer forming the *walls of the lumen* is a spiral much the same as the outer spiral, but differs from it greatly in its chemical composition. This is determined from a microscopical study of the fiber while under a cuprammonia treatment.

5. *The substance in the lumen* is structureless and, as is proven by a microscopical test, is of a nitrogenous nature.

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